who ſay that the cubic foot contained a quadrantal of wine; and as little to believe that theſe two ſtandards were ever truly adjuſted to each other.

But had the original ſtandard of the Roman foot been truly adjuſted to the quadrantal, and continued invariable from the time of its firſt eſtabliſhment, yet a falſe meaſure of it might at one time or other have got into common uſe at Rome, as well as a falſe meaſure of the French foot did at Paris; where in the year 1668, the maſon's foot was found to exceed the foot of the Chatelet by $\frac{5}{72}$ of a Paris inch (9), which is above $\frac{1}{14}$ of a London inch: and the unaccountable negligence which appears in the Roman coinage, gives ſufficient ground to ſuſpect they were not more accurate in their meaſures.

LXX. *A Deſcription of a metalline Thermometer; by* Keane Fitzgerald, *Eſq; F. R. S. Communicated by the Right Hon.* George *Earl of* Macclesfield, *Preſident of the Royal Society.*

Read May 22, 1760.

IT is univerſally allowed, that all bodies, whether ſolid or fluid, are expanded and contracted by heat and cold; and, as far as experiments of this kind have yet reached, it appears, that ſcarce any two bodies of different natures, or even of the ſame; are expanded, or contracted equally by the ſame degrees.

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(9) Picard, in the paper De Menſuris, quoted above.

The

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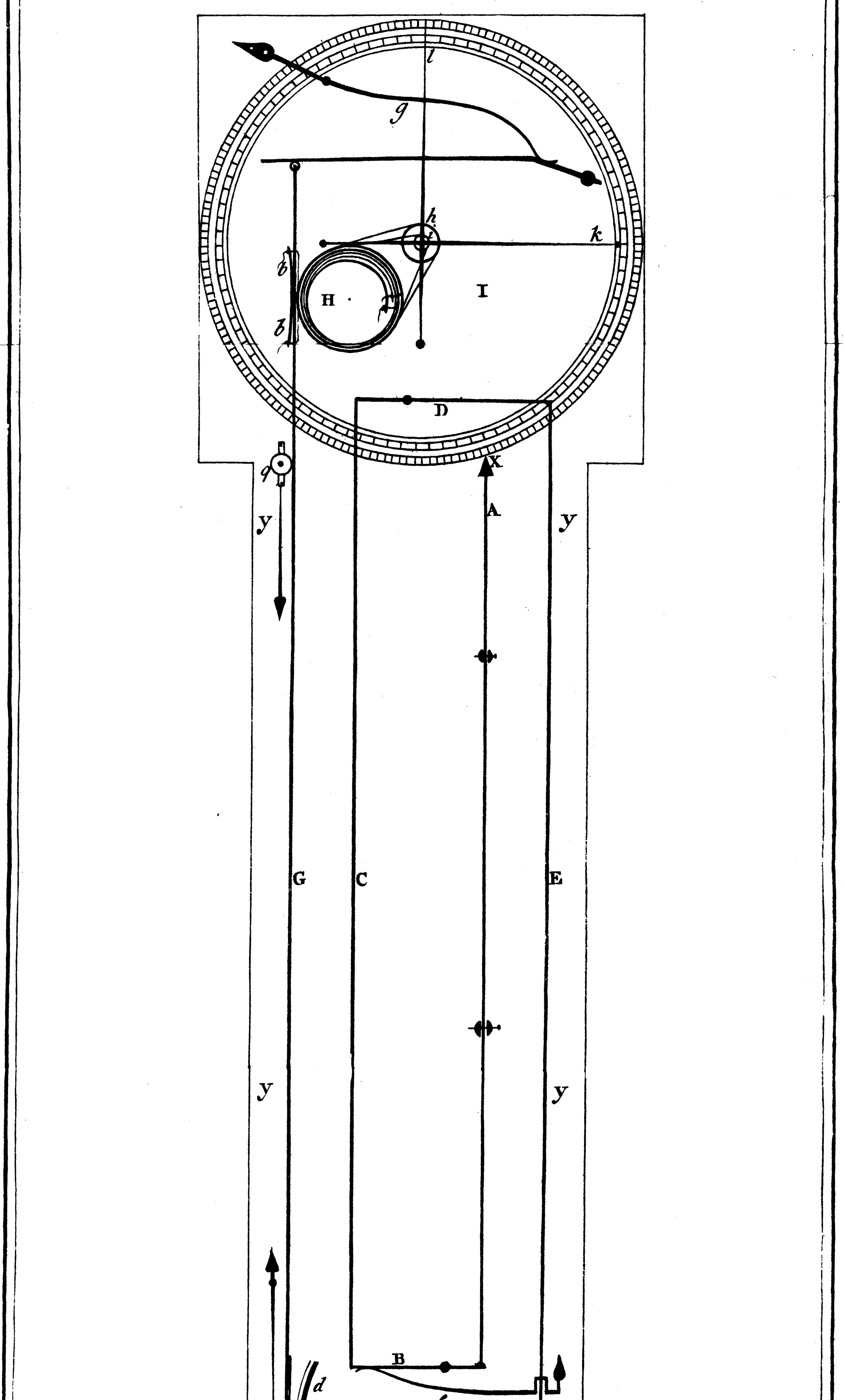
The advantages that may be derived from being able, by proper inſtruments, to aſcertain the degrees of natural and artificial heat and cold, with reſpect to philoſophical inquiries; and alſo to ſeveral uſeful, and common purpoſes in life; have induced many ingenious perſons to apply their thoughts that way; and endeavour to form ſome certain ſtandard, or gage, by which this may be obtained. The three principal bodies that have been made uſe of for this purpoſe; are air, alcohol, and mercury.

Mr. Boyle, the great promoter of experimental philoſophy, made a thermometer on the principle of air, which, to a certain degree of heat or cold, anſwered very minutely. Alcohol, or ſpirit of wine, has been more generally uſed; but has been found to loſe, in time, much of its expanding quality; and alſo to be frozen by an intenſe degree of cold. Mercury, as not deemed ſubject to theſe inconveniencies, has therefore been allowed the moſt proper for the purpoſe.

The learned Dr. Halley has obſerved, that mercury expands very ſenſibly at firſt, attaining very nearly the ſame height, ſome time before the water boils, in which it is placed; that it does on the ſtrongeſt boiling: whereas ſpirit of wine expands gradually, as the heat increaſes; but ſlower at firſt, and faſter after it is well warm; and, at a certain degree of heat, which wants much of boiling water, being almoſt tolerable to the touch, it boils vehemently; emitting bubbles, which, coming into the neck of the thermometer, lift the incumbent ſpirit to the top: from whence he concludes, that the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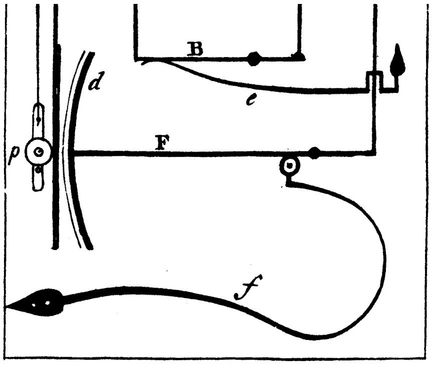

J. Mynde ſc.

expanſion of fluids graduated by equal parts, is not a ſufficient ſtandard of heat and cold.

Mr. Fahrenheit has ſince improved the mercurial thermometer to a great degree, and brought it to as much perfection as, perhaps, it will bear. He has remarked, that when the barometer ſhews a greater degree of preſſure of the atmoſphere; the ſame liquor will receive eight, or nine degrees of heat, more than when the barometer is at the loweſt. But whether this proceeds entirely from the liquor's receiving a greater degree of heat, by the preſſure of the atmoſphere, may be a matter of ſome doubt; as it ſeems, by comparing the mercurial, with other thermometers; to be affected, in ſome meaſure, by the preſſure of the atmoſphere, in all degrees of heat and cold.

The making of metalline thermometers has been hinted at by many; particularly by Mr. Smeaton, in his curious obſervations on the expanſion of metals, who recommends zink, or ſpelter, as moſt capable of expanſion, and fitteſt for the purpoſe. I have endeavoured to make one on this principle, which I take the liberty of laying before this Society, with a deſcription of its conſtruction, and an account of the few obſervations I have been as yet able to make on it. [*Vide Tab.* XVIII.]

It is compoſed of four metal bars, which act by a combination of levers, and pullies. The upper end of the bar A, which is 2 feet long, is oppoſed by a flat piece of metal *x*, ſcrewed faſt to a piece of deal board; *y*, *y*, *y*, *y*, and its lower end reſts on a ſmall hemiſphere, placed on the ſhorter arm of the lever B, which is fixed to the board *y*.

By

By the expanſion of the bar A, the ſhorter arm of the lever B is preſſed down: and as the ſpace deſcribed by each of the points of a lever is as the diſtance from the fulcrum; ſo the longer arm of the lever B, which is 2½ as long as the other; is raiſed proportionably; and the ſecond bar C, 2 feet 2 inches long, the lower end of which is placed to the point of the lever B, by a ſmall pin, round which it is moveable; and the upper end, in like manner, to the ſhorter arm of the ſecond lever D; is raiſed accordingly; and thereby the longer arm of the lever D, which is 2¾ as long as the other, is proportionably preſſed down; to which is added the expanſion of the bar C, increaſed, in like manner, by the lever D.

The third bar E, 2 feet 4 inches long, is placed to the point of the longer arm of the lever D, and the ſhorter arm of the third lever F, which it preſſes down accordingly; and the longer arm of this lever, which is four times as long as the other, is thereby proportionably raiſed; to which is alſo added the expanſion of the third bar E, increaſed by the lever F.

There is an arch-head *d*, fixed to the point of the longer arm of the lever F, to which the fourth bar G, 3 feet long, is fixed by two chains, which raiſe and lower it, as that arm riſes or falls; and, at the diſtance of 2 feet 6 inches, there is a pulley H, 3 inches diameter. There are two cords fixed to this pulley, ſurrounding it different ways, one leading upwards, the other downwards, which paſs through the bar G, and are fixed to two ſprings *b*, *b*, which keep them equally tight; and the bar cloſe to the

the pulley H, which is turned different ways, as the bar G is moved upwards or downwards.

There is a pulley *p* fixed on the other ſide of the bar G, oppoſite the arch-head of the lever F, on which the bar rolls; and which, by the help of a ſlender ſpring, keeps it cloſe to the arch-head; towards the upper end, there is another pulley *q*, on which it alſo moves.

The expanſion of the bar G, from the place where it is fixed to the arch-head *d*, to the place where it is fixed by the ſtrings to the pulley H, is to be added to the expanſion of the other three bars, increaſed by the ſeveral levers.

There are two ſmall pullies *h* and *i*, the pulley *h* one inch diameter, and the pulley *i* a quarter of an inch diameter, whoſe axis paſſes through that of the pulley *h*, like the hands of a clock; and on theſe are placed, in like manner, two indexes *k* and *l*, which move round the dial I, that is 12 inches diameter. Theſe pullies are ſurrounded by cords, which alſo ſurround, and are faſtened to ſprings within the pulley H. The index *l*, which may be called the minute-hand, is moved 4 times round for once the index *k* is moved round; the index *l* ranges at its extreme point 48 times as much as the bar G riſes or falls; and the index *k* 12 times.

As the powers of theſe levers are all reverſed, with reſpect to the preſſure by the expanſion of the bars; there are two counterballance ſprings *e* and *f*, placed under the longer arms of the levers B and D, which help to raiſe the bars eaſily; and there is another ſpring *g*, acting on a ſmall roller, placed on the top of the bar G, which returns all the bars on their contraction.

On the dial-plate I, there are three circles deſcribed. The inward circle is divided into 240°, according to Fahrenheit's ſcale. The middle circle is divided into 360°, which is intended to mark the expanſion of different metals. The outward circle is divided into 1080 parts, to which the longer index *l* points, which marks 18 diviſions for each degree of the inward circle; and 12 for each degree of the middle circle, pointed to by the index *k*.

The quarter diviſions of the dial are marked I, II, III, IIII, to ſhew, by the index *k*, how often the index *l* has gone round.

There is a ſcrew-hole towards the point, in the index *k*, to fix a ſmall pencil in; which is moved by the index on a circle of wood, or ivory, and marks the higheſt and loweſt degrees it has pointed to, for any time; which ſaves the continual examination requiſite to form obſervations of this kind; and the mark of the pencil is eaſily rubbed out, when any new obſervation is intended.

The firſt bar A of this inſtrument may readily be taken out, and replaced; or any other bar of equal length and thickneſs applied; by which means, the inſtrument may be uſed as a pyrometer, to meaſure the expanſion of any bar 2 feet long, with great exactneſs, to the 73,840th part of an inch *per* foot; and, as a thermometer, it marks the alterations in the temperature of the air, much more ſenſibly than any other inſtrument for the purpoſe; the range of the minute index *l* being 74 inches, by the common degrees of heat and cold of this climate.

If the greateſt expanſion, from freezing to boiling water, of the metal bars to be made uſe of in an inſtrument of this kind, is certainly known; it may be made to mark any minute degree intended. But to anſwer a calculation of this kind; the levers, and pullies, muſt be made with the greateſt exactneſs; which I could not prevail on the workman that made mine to be ſo careful of as I could wiſh. It is eaſy, however, to come to a certain knowlege of the expanſion, mechanically. I took a thick book, and preſſing the leaves between my finger and thumb gently; meaſured off an inch exactly, with a pair of compaſſes, from the 1ſt page, which made 568 pages. I cut off ſeveral ſlips from different leaves, each of which I placed between two bits of watch-ſpring, which were marked, in order to place them in the ſame poſition exactly, on each trial. On examining theſe with the inſtrument, I found but few of an exact thickneſs; but that, on a medium, each leaf raiſed the minute index 130 diviſions. So that the number of pages, each leaf of which is the 284th part of an inch, multiplied by the number of diviſions it raiſes the index; ſhews, that each diviſion marks the 73,840th part of an inch expanſion *per* foot of the bar A, which is 2 feet long.

This bar is made of ſpelter, which is of ſo brittle a nature, as makes it difficult to file one of that length without breaking. If it is not well caſt, it will be extremely hollow; as was the caſe of a bar I made uſe of, which did not expand near as much, nor as uniformly, as another of the ſame metal, and contracted much more readily; which I could not well account for, until it broke by accident; when it appeared full of large cavities on the inſide, though the outſide ſeemed as fair as any other. Some of theſe cavities were above an inch long, and the ſurrounding metal, after filing, not above the thickneſs of a card. I would therefore recommend the weighing bars of this metal, in order to obſerve the difference of expanſion.

The other bars of this inſtrument, as the founder informs me, are made of 18 parts ſpelter, and 2 of copper. I ſhould imagine, that there is a greater proportion of copper than he owns, from the appearance of the metal, and the diſproportion in its expanſion, to what I ſuppoſe 2 parts in 20 might occaſion.

Since this inſtrument has been made, I found, on looking over the 10th volume of Martin's Abridgment of the Philoſophical Tranſactions; that Dr. Mortimer had, in 1735, given the Royal Society a deſcription and drawing of an inſtrument he invented for the purpoſe; and that Mr. Johnſon had alſo given a drawing of another, invented by Mr. Fothringham. Although theſe are of a very different conſtruction, yet, as they were formed on the ſame principles, I ought, in juſtice to theſe gentlemen, to mention them.

I have made what obſervations I could on this inſtrument, ſince the ſhort time it is made; by comparing it with a Fahrenheit's, and a ſpirit thermometer; and find, that it keeps at a medium between both; not riſing at firſt ſo quick as the mercury, and ſomewhat quicker than the ſpirit. On placing them together in the ſun, when its heat became intenſe, it roſe at laſt faſter than the mercury, and not ſo faſt

as

as the ſpirit; and continued to riſe for ſome time after the others became ſtationary.

I electrified the bars of the inſtrument, to ſee if the electrical fire could produce any degree of heat ſufficient to expand them; which, on the firſt trial, it ſeemed to do, by the minute index riſing 6 diviſions in a ſhort time. But as I had ſome reaſon to imagine; that this appearance proceeded rather from an increaſe of heat, occaſioned by two gentlemen being in the room with me, when I made the experiment; I repeated it alone the next day, leaving the door open at the time, and could not perceive the minute index to riſe above one diviſion; which I attribute rather to the warmth that my being in the room had occaſioned.

I tried the expanſion of a few metal bars, from artificial freezing, with pounded ice, and water that it diſſolved into; upon which was poured half an ounce of ſpirit of tartar, in which Fahrenheit's thermometer deſcended to within one degree only of the freezing point: to boiling water, in which it roſe to 211°, though the water did but ſcarce boil, for want of a ſufficient number of lamps. The barometer ſtood at 30 inches, and the natural heat of the weather at 60° of Fahrenheit.

	Diviſions.
* A bar of ſpelter 2 feet long, marked by the minute index — — — — — —	1570
Spelter 18 parts, and copper 2 parts, according to the founder's account — — —	1150
Braſs — — — — — — — —	1120

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* This was the bar, found, on breaking, to be hollow.

Iron

	Diviſions.
Iron	785
Steel	695

Note. Each diviſion marks the 73,840th part of an inch expanſion *per* foot.

I find that theſe come ſomewhat near Mr. Smeaton's table. They are far from being as complete as I wiſh; but hope to be able to give a more accurate account hereafter; as it certainly requires the natural cold to be added to the artificial, in order to get at the laſt degree of the contraction of metals, which can be come at in this climate.

If an inſtrument of this kind ſhould be deemed worthy the attention of the curious, there is no doubt, but it may be carried to a much greater degree of perfection than this, which is but a rude beginning. The friction is little or none, as the ſpring at the top of the fourth bar, keeps the ſeveral levers and bars in the ſame poſition on their axes, whether riſing or falling. It may be made much more eaſily, and at a leſs expence, by making uſe of counterballance weights, inſtead of ſprings; and by a cord paſſing over a pulley placed on the top of the fourth bar, with a weight fixed to it, which returns the bars, on their contraction.

I have one making in this manner. The firſt bar of which is 3 feet long, and by a ſlider, which is fixed by a ſcrew, it will meaſure the expanſion of any bar, within that length. The powers of the levers are alſo greater; and the minute hand goes 12 times round, for once the other goes round; by which it marks the 300,000 part of an inch expanſion *per* foot, and ranges 216 inches, by the common degrees of heat and cold in this climate.

Mercury cannot be uſeful in trying any degrees of heat above what makes it boil: and it appears by Dr. Hinſell s account of the experiments lately made at Peterſbourg, that it may be frozen by extreme cold; which makes it unfit for aſcertaining the extreme degrees of either.

An inſtrument of this kind might be made by the help of a tin caſing, to come between the bars and the wood, to receive a bar of iron or ſteel, heated to any degree within that of its melting; without any detriment to it. And any kind of metal bar will certainly bear the moſt extreme degree of cold, and probably contract proportionably. I ſhould imagine it might alſo be made very uſeful in trying minutely the expanſion of different kinds of metals, fit for making compound pendulums; and the exactneſs of the pendulum, when made, might likewiſe be tried, by artificial freezing, or in hard froſt, and by boiling it in water.

LXXI. *An Account of a Bird ſuppoſed to be bred between a Turkey and Pheaſant; by Mr.* George Edwards, *F. R. S.*

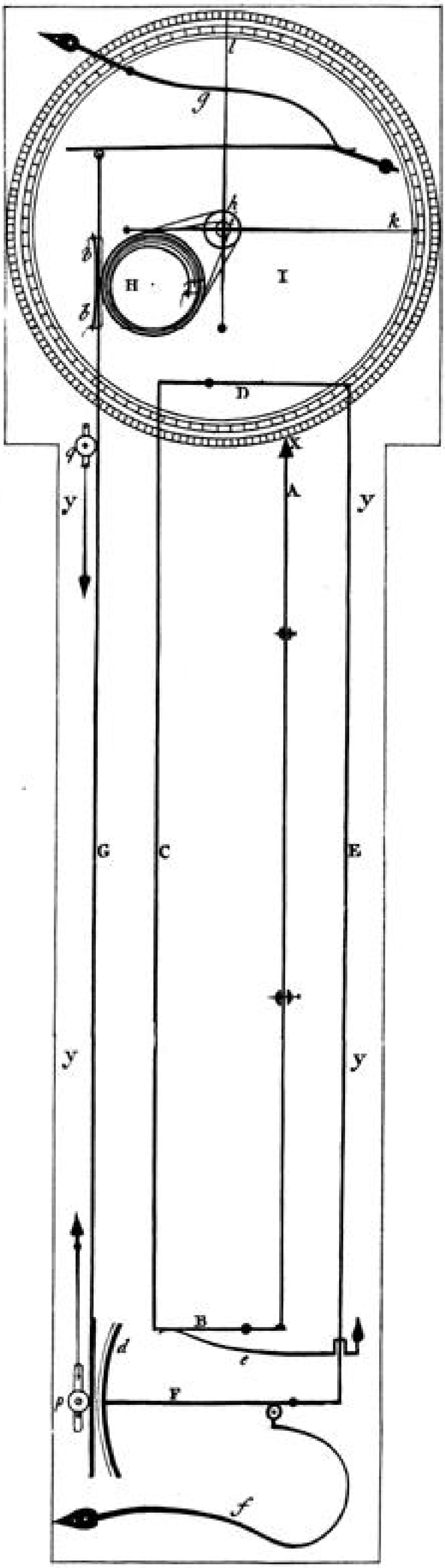
To the Rev. Dr. Birch, *Secretary to the Royal Society.*

S I R,

Read May 22, 1760.

HAving in my hands a bird, that, I believe, may be a curious and entertaining ſubject to the Royal Society, I preſume, by your favour, to lay it before them [*Vide Tab.* XIX.], with its deſcription, and what other account of it I could

Philos. Trans. Vol. LI. TAB. XVIII p. 825.



J. Mynde sc.